Evaluating Fish Community and Habitat Quality using the Index of Biotic Integrity and the Quality Habitat Evaluation Index Along York Prairie Creek and Jake's Creek, Delaware County IN.

An Honors Thesis (HONRS 499)

By

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ABSTRACT

The objective of this study was to relate the quality of the fish community with the quality of the habitat using the Index of Biotic Integrity (IBI) and Quality Habitat Evaluation Index (QHEI) in York Prairie and Jake's creeks, Delaware County IN. Four locations were chosen at bridge sites in each stream from the most upstream waters to the mouth. At each sample location point, the upstream reach was typically sampled and evaluated independently for both IBI and QHEI. Sampling was conducted by using a backpack electrofishing unit and a total of 24 fish species were collected from the eight sites. IBI scores ranged from 20 to 28 and QHEI scores ranged from 43 to 67. A significant positive correlation between IBI and QHEI scores was observed. In addition to this, a significant positive correlation was also found between the IBI scores and one of the individual QHEI metrics (channel morphology). A positive relationship was found between the IBI scores and two other individual QHEI metrics (riparian zone and bank erosion and instream cover), but this correlation was not shown to be significant. Sites were found to have IBI scores that reflected the habitat conditions. Low QHEI scores and IBI scores point to poor habitat and water quality along the creek due to anthropogenic influences that negatively affected the fish populations.

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INTRODUCTION

As the intensity of agricultural activity increases, increased siltation of stream habitats and stream channel erosion occur and negatively influence fish populations by decreasing production and diversity (Berkman and Rabeni 1987). Further stream degradation occurs with channelization causing increases in sediment loads, erosion, and gradients, while decreasing riffle and pool abundance, riparian zones, canopy cover, and stream sinuosity (Emerson 1971, Etnier 1972, Chapman and Knudsen 1980, Berkman and Rabeni 1987, Shields et al, 1998, Wichert and Rapport 1998, Walser and Bart 1999). When the stream environment is degraded, the fish community associated with it also suffers (Etnier 1972, Gorman and Karr 1978, Scarnecchia 1988, Walser and Bart 1999, Schiemer 2000).

East Central Indiana has an agricultural landscape that covers approximately 70% of the land and is typical for the Indiana and Midwestern region U.S. (National Agricultural Statistics Service 1997, Indiana Agricultural Statistics Service 2000). Many of the streams in this region have been channelized in the past and are in various stages of recovery. The objective of our study was to examine the relationship between habitat and fish community quality, focusing on the effects of channelization in two of these streams. Fish quality was defined using the Index of Biotic Integrity (IBI) following Simon and Dufour (1998), while habitat was evaluated using the Quality Habitat Evaluation Index (QHEI) (Rankin 1989). We also determined which components of the QHEI had the largest influence on the structure of the fish community.

METHODS AND MATERIALS

Eight sites located in East Central Indiana (Delaware county) were chosen for our study on two small streams: York Prairie and Jake's creeks (Figure 1). York Prairie Creek is a tributary of the White River and Jake's Creek is a tributary of Killbuck Creek. Over 70% of the land use in this area is agricultural (Indiana Agricultural Statistics Service 2000) and all have been historically channelized. Both streams are in a state of recovery, but still show little meandering and a mostly straight channel.

Sampling was conducted over a two-day period in late August 2003. Fish were collected using a backpack electrofishing unit following the Index of Biotic Integrity (IBI) proposed by Simon and Dufour (1998) designed for the East Central Corn Belt Plain. The distance sampled for all sites was 15 times the wetted width of the stream. All fish were collected and preserved in 10% formalin and taken back to the lab for identification and analysis. Identification was according to Pflieger's Fishes of Missouri (1997). The fish were then weighed, measured, and examined for anomalies and stored in 95% Ethyl alcohol. Individual IBI scores were calculated for each site based on the associated fish collections.

The habitat was evaluated based on the Quality Habitat Evaluation Index (QHEI) (Rankin 1989), and was conducted at each site the time of the fish collection. The procedure measured six metrics: substrate, in-stream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle/run quality, and gradient. Scores for each metric were calculated and summed to provide a total score for each site. Gradient measurements were calculated from the United States Geological Survey topographic maps having a scale of 1:24,000.

A Pearson's Correlation analysis was used to determine whether habitat quality was associated with the quality of the fish community by comparing the IBI and QHEI values at each station. In addition, a correlation was run between the total IBI score and each individual QHEI metric (6 ea.) to determine specific associations between habitat conditions and fish quality.

RESULTS

Twenty-four species were collected from eight sites in the two streams (Table 1), with the total number of species collected at each site ranging from 2 to 15. Sensitive species (Simon and Dufour 1998) were found in both streams and included: greenside darter, horneyhead chub, rock bass, and rosyface shiner. Four tolerant species were found at over half of the sites and included: blacknose dace, bluntnose minnow, creek chub, and green sunfish. Other tolerant species found at less than half of the sites included: common carp, white sucker, and yellow bullhead. Other species that did not fall into either classification category according to Simon and Dufour included: bluegill, central stoneroller, johnny darter, largemouth bass, and orangethroat darter (present in at least half of the sites) and blackstripe topminnow, mottled sculpin, redfin shiner, ribbon shiner, silverjaw minnow, spotfin shiner, striped shiner, and tadpole madtom (present in less than half of the sites).

Index of Biotic Integrity scores (Figure 2) ranged from 20 to 38 with the lowest scoring site located at an upstream headwater site along York Prairie Creek. Fish were found here in small pools with little to no flow that was perceptible at the site. The highest scoring site was located at the farthest downstream site along York Prairie Creek. Sites with higher IBI scores had low percentages of tolerant species as well as high diversity of species at that site. The majority of our IBI scores fell within the poor category according to Simon and Dufour (1998). Ranges of the IBI scores for the two streams were York Prairie Creek, 20 to 38, and Jake's Creek, 22 to 37.

Qualitative Habitat Evaluation Index (QHEI) calculations ranged from 43 to 67. In general, the lowest scores appeared to come from sites where there was the most extensive channelization present. This channelization influenced the substrate types and channel morphology metrics at both streams. Some degree of channelization (categorized as recovered or recovering in the QHEI channel morphology metric) was noted at all 8 sites. All of the sites had low sinuosity, which further decreased quality habitat scores at that site. The lowest scoring site was a headwater site found on Jake's Creek. This site was a quarter mile down stream from a trailer park with a marginal, or faulty septic system. This site had no channelization, major bank erosion, and virtually no pools or riffles present. Also the velocity was constant throughout creating a habitat lacking diversity. The very last site of York Prairie Creek gave us the highest score with a score of 67. This site had virtually no bank erosion, extensive instream cover, fairly well developed pools, glides, riffles, and runs as well as diverse velocities.

A positive correlation between QHEI and IBI scores at each site was identified ($n=8$, $r^2=0.51$, $p=0.047$), indicating that fish community quality improved with increasing habitat quality (Figure 2). Individual QHEI metric scores (6) were correlated with the overall IBI scores to identify specific habitat components that influenced the fish community (Table 2). From this analysis, changes in channel morphology were found to have the largest influence on fish community assemblages in these two streams. Riparian zone and bank erosion and instream cover were found to have some influence on fish community and IBI scores. Most of the riparian zones for our sites ranged from very narrow to moderate, with the average being narrow. The wider the riparian zone, the less runoff that occurs, increasing and improving fish community diversity. This analysis also showed that gradient, pool/glide and riffle/run quality, and substrate type had no influence on the IBI scores for the two streams sampled. This was expected because all of the sites had a similar gradient, as well as similar substrate types and pool/glide riffle/run quality. Since there were no real differences between sites, no significant results were expected.

DISCUSSION

Agriculture, such as found in East Central Indiana, severely changes the natural landscape; including the removal of riparian zone vegetation, the addition or removal of nutrients to the soil, denuding the vegetation during portions of the year, and the channelization of streams (Hupp 1992, Wichert and Rapport 1998, Walser and Bart 1999). These modifications in the terrestrial use focus on increasing efficiency and profit for the agricultural industry. However, they also negatively impact the aquatic communities associated. Our findings for two East Central Indiana streams suggest that as the terrestrial habitat was increasingly altered from agricultural practices, the fish community quality was correspondingly lowered. These findings are similar to other studies in this type of landscape (Walser and Bart 1999, Schiemer 2000).

Channel morphology was the most influential habitat parameter on fish community quality in these two streams. All of the eight sites were in some stage of recovery from channelization, with most still showing a morphologically straight channel (QHEI metric: channel morphology). When a channel is straightened and shortened, al riffle and pool habitats are removed (Carline and Klosiewski 1985), lowering habitat diversity (Etnier 1972, Gorman and Karr 1978, Chapman and Knudsen 1980, Carline and Klosiewski 1985, Portt et. al 1986, Scarnecchia 1988, Hupp 1992, Muotka et. Al 2002). A channelized stream is a fast flowing run, or typically, a stream with a high, non-turbulent velocity having a depth deeper than a riffle (Rankin 1989). Because channelization causes a higher velocity, a higher gradient and an increase in erosion, the substrate is extremely unstable and lacks variability (Emerson 1971, Etnier 1972).

This reduction in stream habitat quality due to channelization reduces fish community quality (Etnier 1972, Gorman and Karr 1978, Scarnecchia 1988). This finding is supported by observations in our study area. For example, our lowest scoring IBI site on York Prairie Creek was a headwater site that was recovering from being channelized. We found no riffles, very little to no flow, and low sinuosity. We collected only two species, likely due to the lack of riffle and pool habitats available. In contrast, the highest IBI score was found on York Prairie Creek at the farthest downstream site. Here we found a total of 15 species, only 31% of which were considered to be tolerant species. We also found three darter species, indicating fairly well developed riffle habitat and substantiating the relationship between land use and fish community quality.

The environmental tolerance of the fish community is related to the level of stream degradation (Rankin 1989, Smoger and Angermeier 1999). A channelized stream lacks a high abundance of sensitive species while becoming dominated by tolerant species that have the ability to survive and thrive in environments altered by anthropogenic practices. Sensitive species have a decreased range of environmental tolerance and are typically not found in degraded habitats (Smoger and Angermeier 1999). We found that the highest scoring QHEI sites had the lowest percent of tolerant individuals and the highest percent of sensitive individuals. Contrastingly, the lowest scoring QHEI sites had the highest percent of tolerant individuals and the lowest percent of sensitive individuals.

Our findings indicate that habitat quality degradation occurred long after channelization took place. Diversity and stability of the stream communities only occurs after a period of recovery that allows succession (Hupp 1992, Muotka et. al 2002). If the stream channel is restored and anthropogenic practices are minimized, diverse habitats, such as water velocities, instream cover, and variable substrates are re-established. A diverse fish assemblage is expected at sites that have well developed habitats and poor fish assemblages are expected at sites with poorly developed habitats (Scarnecchia 1988). According to this model, tolerant species are expected to be the first to colonize and sensitive species are expected to colonize only after riffle and pools were restored. In our study, the highest scoring site was composed of only 31% tolerant species and the lowest scoring site was composed of almost 83% tolerant species. Both of these sites were on York Prairie Creek. This suggests that only the most pristine conditions in this region were able to support a diversity of fish species, while lower scoring (poorer habitat quality) sites were only able to support tolerant species and would need to be re-established before being able to support more sensitive species.

Variation in gradient, pool/glide and riffle/run quality, and substrate type had no effect on fish community assemblages for the streams sampled. There was little difference in gradient between the two streams and pool/glide and riffle/run quality as well as substrate types were almost identical between the two streams. Thus, with no difference in this metric between the sites, no significance was detected. However, we still feel that these three factors are important in the makeup of fish community assemblages.

Anthropogenic practices have caused the stability of the fish assemblage to be lost. Even if a stream is left to recover or be restored to its natural condition, the diversity of the fish assemblage may slowly re-establish, but the assemblage will not be stable. Stability of a fish assemblage cannot be achieved until all of the anthropogenic practices that negatively affect the lotic environment are discontinued in that watershed (Gorman and Karr 1978). This points to the need for increased land management enforcement that especially targets the most influential and significant factor, channelization of streams.

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Table 1. List of fish species found in East Central Indiana streams, along with frequency of occurrence (n max = 8) and tolerance category.

Species	Scientific Name	No. Stations	Classification
Blacknose dace	*Rhinichthys atratulus*	5	Tolerant
Blackstripe topminnow	*Fundulus notatus*	1	-
Bluegill	*Lepomis macrochirus*	4	-
Bluntnose minnow	*Pimephales notatus*	6	Tolerant
Central stoneroller	*Campostoma anomalum*	6	-
Common carp	*Cyprinus carpio*	1	Tolerant
Creek chub	*Semotilus atromaculatus*	7	Tolerant
Green sunfish	*Lepomis cyanellus*	7	Tolerant
Greenside darter	*Etheostoma blennioides*	3	Sensitive
Horneyhead chub	*Nocomis biguttatus*	1	Sensitive
Johnny darter	*Etheostoma nigrum*	6	-
Largemouth bass	*Micropterus salmoides*	6	-
Mottled sculpin	*Cottus bairdii*	1	-
Orangethroat dartér	*Etheostoma spectabile*	6	-
Redfin shiner	*Lythrurus umbratilis*	1	-
Ribbon shiner	*Lythrurus fumeus*	1	-
Rock bass	*Ambloplites rupestris*	2	Sensitive
Rosyface shiner	*Notropis rubellus*	1	Sensitive
Silverjaw minnow	*Ericymba buccata*	2	-
Spotfin shiner	*Cyprinella spiloptera*	1	-
Striped shiner	*Luxilus chrysocephalus*	1	-
Tadpole madtom	*Noturus gyrinus*	1	-
White sucker	*Catostomus commersoni*	1	Tolerant
Yellow bullhead	*Ameiurus natalis*	2	Tolerant

Table 2. Correlation between total IBI and QHEI (total and individual metrics) scores for eight sites in two East Central Indiana streams.

	p	r^2
QHEI (Total score) vs. IBI	0.047	0.51
QHEI (Individual metrics) vs. IBI		
Channel Morphology	0.027	0.58
Riparian Zone and Bank Erosion	0.128	0.34
Instream Cover	0.199	0.257
Gradient	0.578	0.054
Pool/Glide and Riffle/Run Quality	0.915	0.002
Substrate	0.948	0.007

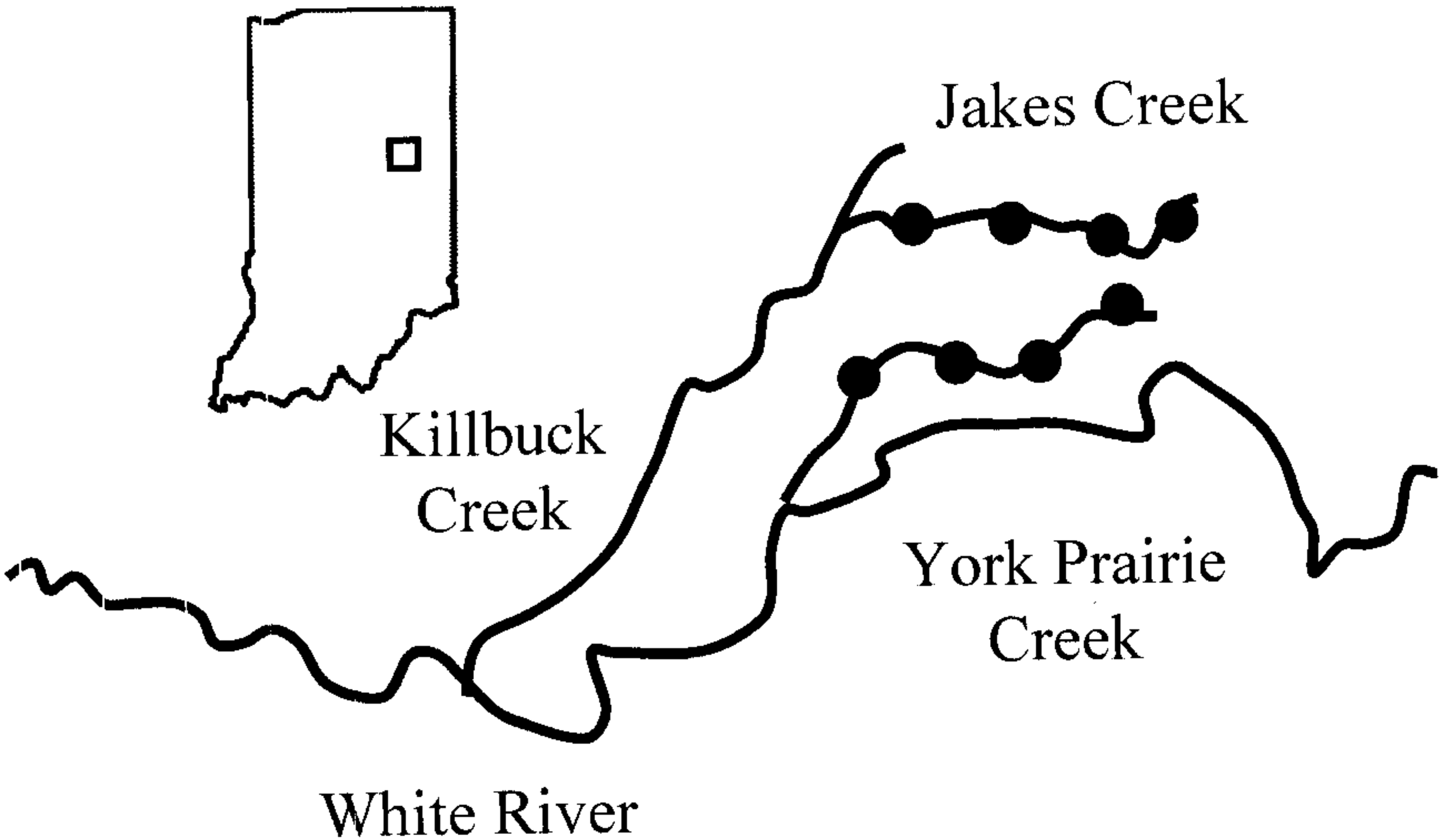

Figure 1. Map of sample sites located on York Prairie and Jake's creeks in Delaware County, Indiana.

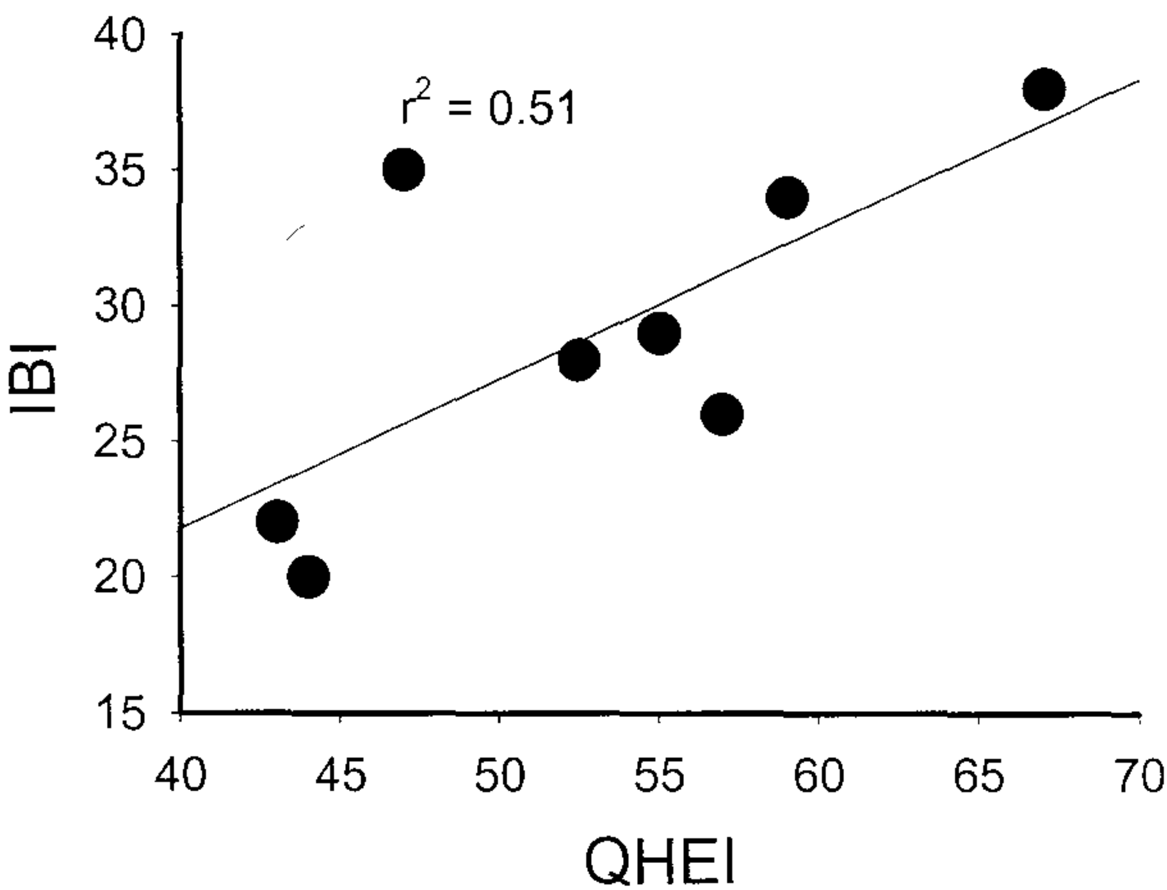

Figure 2. Relationship of IBI and QHEI scores for eight East Central Indiana sites ($p = 0.047$).